AFOSR 68-2167

In Press
Psychophysiology.

AD 677608

Heart Rate Response to Sound and Light

Robert Roessler, Forrest Collins and Neil R. Burch

Psychophysiology Laboratory, Department of Psychiatry, Baylor
University College of Medicine and Psychophysiology Division,
Texas Research Institute of Mental Sciences, Houston, Texas

Cat-04
pages - 30
Code - 1
CR# 98918
AD 677608

Address reprint requests to Dr. Robert Roessler, Department of
Psychiatry, Baylor University College of Medicine, Houston, Texas,
77025.

ABSTRACT

The heart rate (HR) response to five intensities of sound was examined in 18 subjects and to five intensities of light in 12 subjects. Each subject was tested on four occasions at monthly intervals. After covariance adjustment, significant acceleration to sound was found within the first 5 beats after stimulus onset but no significant deceleration occurred. There were no differences between testings. Individuals' HR acceleration was reliable over testings and differing experimental contexts. No habituation occurred and no consistent relationship between HR response and ego strength was found. There was no significant HR response to light stimulation. The results were discussed in relation to Graham and Clifton's (1966) hypotheses concerning the relationship of the HR response to the orienting reflex (OR).

DESCRIPTORS: Heart rate, Sound stimulation, Light stimulation, OR, Personality, Habituation. (R. Roessler)

Heart Rate Responses to Sound and Light

Robert Roessler, Forrest Collins and Neil R. Burch

A number of recent studies have focused upon the direction of heart rate (HR) response to various types of stimulation.   Much of this research appears to have been stimulated by the provocative hypothesis of the Laceys (Lacey, Kagan, Lacey & Moss, 1963) that stimuli which evoke attention to the environment induce cardiac deceleration while those evoking "rejection of the environment" induce acceleration.   Obrist (1963) has confirmed the Laceys' findings.

Considerable controversy has arisen regarding the nature of the HR response, however, and apparently contradictory results have been obtained in various experiments.   Campos and Johnson, for example, have challenged the Laceys' hypothesis and results in two recent studies (1966, 1967).   They concluded that instruc- tions to verbalize produce acceleration in response to a variety of stimuli, while the absence of such a require- ment with the same stimuli resulted in HR deceleration.   Weiner (1962) had previously emphasized the acceleration effects of the verbalization requirement.

In an earlier experiment (Roessler, Alexander and Greenfield, 1963), the degree of HR response to sound

was related to the ego strength personality dimension,
although not significantly so. In that experiment
verbalization was required. The HR data from the
present experiment, in which verbalization was not
required, were also examined for a possible relation-
ship to ego strength.

Graham and Clifton (1966) have reviewed the studies
through 1965 which are relevant to the HR increase-
decrease controversy. They refer to additional prob-
lems which have complicated the interpretation of such
experiments. One is the use of complex stimulus
situations, the many parameters of which make it
difficult to ascribe differences to the effect of any one
of these parameters. In this experiment only simple
quantified stimuli were employed.

Another problem which makes comparison among
experiments difficult is the scoring of the HR response.
Campos and Johnson used averages of HR scored every
15 seconds for one minute pre-and post-stimulus; Lang
and Hnatiow (1962) used the difference between the
fastest rate in the first five beats after stimulus onset
and the slowest in the next fifteen beats; Johnson and
Lubin (1966) used a similar but modified score;

Dykman's group (Galbrecht & Dykman, 1965) used the fastest rate in the five seconds preceding stimulus onset subtracted from the fastest rate during a five second stimulus; other investigators have used a wide variety of scores. Obviously, there might be considerable divergence in results depending upon what score was used. In this experiment, therefore, there was a further examination of the beat-by-beat HR response to stimulation and a comparison of four scores derived from this examination.

It is of particular interest, in view of the acceleration-deceleration controversy, that some of the investigators employing beat-by-beat analyses have found both accelerative and decelerative phases in HR responses to the same stimulus (Uno and Grings, 1965; Lang and Hnatiow, 1962; Geer, 1964; Myers and Gullickson, 1967). Discussing such experiments, Graham and Clifton suggest that the decelerative component of the HR response to simple, non-signal, stimuli is the orienting component (OR) and that the accelerative component is the defense response. They therefore hypothesized that: 1) The deceleration component will habituate over trials; 2) higher intensities of stimulation will evoke acceleration (a defense response) but little, if any, deceleration, and 3) the accelerative component

will increase over trials. In a subsequent experiment (Chase and Graham, 1967), only deceleration occurred to both onset and offset of 18 second tones and this response did indeed habituate rapidly. Higher intensities of stimulation did not evoke acceleration but the highest intensity was only 87 decibels (db) presented over a 71 db background of white noise. A wider range of stimulus intensities was employed in this study.

Many of the studies showing accelerative HR responses have employed auditory stimuli. It is possible, as Graham and Clifton point out, that this type of response is modality specific. They noted that the only two studies they found in which other sensory modalities were stimulated failed to show significant acceleratory effects. For this reason, HR responses to light stimulation were also studied in this experiment.

We have been unable to find any study in the literature in which the questions already noted have been examined over time and repeated testings under different conditions. It seems plausible that some of the results obtained are attributable to novelty and unfamiliarity effects or to unquantified variables in the total life situation. In addition, the question of within subject reliability is of interest.

The foregoing issues were examined in the data from the experiment reported here, in which the subjects (Ss) were stimulated with five intensities of sound and five intensities of light on four occasions. There was no task requirement except to pay close attention.

METHOD

A detailed description of the method employed in this experiment is contained in Roessler, Burch and Childers (1966). Only a summary will be provided here.

Ss were 32 male medical and dental student paid volunteers between the ages of 21 and 34. From among the 32 Ss, 18 Ss were selected for analysis of their HR responses to sound stimulation and 12 Ss were selected for analysis of HR responses to light stimulation. Restrictions on the selection of Ss for analysis of the HR data within stimulus modalities were (1) each S had to have HR data on each of four testings (runs), and (2) within modalities, Ss were divided into equal numbers of high and low ego strength Ss, based upon their ego strength (Es) scores from the MMPI (Dahlstrom and Welsh, 1960) and (3) Es groups contained equal numbers of alert and drowsy Ss within runs. These selective criteria substantially reduced the number of subjects available for comparison, especially in the analysis of HR responses to

light stimulation, when many Ss became drowsy.

Ss were tested on four occasions at monthly intervals, January through April. The January testing was a condition of unfamiliarity, the February testing a basal one, the March testing a condition of real life stress (all Ss were tested within 10 days of their comprehensive examinations), and the April testing was another basal one. Ss were told prior to the first testing that we were interested in their physiological responses to various intensities of sound and light, that no pain would be involved, and that each subsequent testing would be identical to the first. They were instructed to keep their eyes closed throughout the experiment and to pay close attention to the lights and sounds because they would be asked questions concerning them after leaving the laboratory.

After five minutes of resting data was recorded, Ss were presented with five different intensities of 1,000 cps sound (40, 94, 100, 106 and 120 db) and, separately, five intensities of white light (24.7, 58, 61.7, 65.5 and 74 db). Each stimulus was of 2 secs. duration. Presentation of all stimuli was programmed to coincide with the onset of 10-second epochs and order of presentation of stimulus modalities was balanced within and across testings. Each of the five stimulus intensities was presented 5 times. Within each modality, stimulus intensity was balanced so that each stimulus was presented

once in each of five blocks of five trials, and so that
each of five inter-stimulus intervals was associated
with each intensity only once in the total 25 stimulus
presentations. Throughout the experiments, the S
lay quietly on a bed with head positioned so that the
light was reflected directly on his eyes. Auditory
stimulation was delivered through earphones.

The electrocardiogram (EKG) was recorded from
the standard EKG lead II position, using 2.0 cm^2
silver-silver electrodes) and commercial Redux
paste. Recording was at a paper speed of 30 mm.
per sec. on one channel of an 8-channel Grass poly-
graph, Model 3D. The R-R periods were hand -
scored to the nearest 0.5 mm. for two pre-stimulus
beats and all of the beats in the 10 secs. following
onset of all stimuli. All periods were then converted
to beats/minute (bpm).

Following the first run all Ss were interviewed
to elicit data on degree of fatigue, intercurrent life
stress, drug ingestion and subjective reaction to the
experiment. They were also asked questions con-
cerning the stimuli such as "How many intensities of
sound were presented?" In later runs this data was
obtained by questionaire.

RESULTS

Figure 1 shows the across Ss mean beat-by-beat HR response for each stimulus intensity in each stimulus modality during the February testing. Mean values for beats after 10 have been omitted because such means reflect only the values of those Ss with faster initial HR. These curves are typical of all four testings and also typical of the single responses of individual Ss, although the latter are more variable. The diphasic nature of the HR response to sound stimulation is apparent, with maximal acceleration occurring prior to beat 5 and maximal deceleration prior to beat 10. Generally, the degree of acceleration and deceleration to sound was also directly related to intensity. Although there was a tendency toward acceleration of HR to light, it was less than half that to sound, was of longer latency and was not related to intensity. The decrease in HR to light did not fall below pre-stimulus levels nor was it related to intensity. Interpretation of this apparent lack of response to light is not clear, however. As previously noted, Graham and Clifton suggested that the decelerative phase may habituate rapidly; this may also be true of the accelerative phase. It is possible therefore, since Fig. 1 shows mean values across all

trials, early and late, that early trials show significant
responses and later trials do not because of habituation.

These possibilities, and the additional questions
posed in the introduction, were therefore approached in
the following manner. Five HR means were computed
for each epoch of stimulation for both stimulus modalities:
1) mean of the two beats prior to stimulation, 2) mean
of the two fastest beats of the first five post-stimulus
beats, 3) mean of the two slowest of beats 6, 7, 8 and 9,
4) mean of the two fastest of all beats in the 10 sec. post-
stimulus epoch, and 5) the difference between the values
of means 2 and 3 above. Mean 4 was computed because it
was the score used in a very similar earlier experiment
requiring verbalization, (Roessler, Alexander and Greenfield,
1963). Mean 5 was computed because Geer (1964) suggested
that it is the "most sensitive measure of cardiac response"
and because it is similar to the Lang and Hnatiow (1962) score.

Type VI three way (Es groups, intensity and subsequence)
analyses of variance for repeated measures (Lindquist, 1953)
on means 2, 3, 4 and 5 above were computed within testings
(runs) for both sound and light.[1] Parallel analyses of co-
variance for repeated measures were also computed, using

mean 1 as the covariant, thereby freeing post-stimulus rates of any pre-stimulus effects. Among the analyses of variance of the HR to light, only two of the subsequence (habituation) terms (runs 1 and 4) for mean 2 were significant and these were not significant after covariance adjustment. There were no significant intensity effects. The only other significant term in the statistical analysis of the HR response to light was the subsequence x intensity interaction on the covariance analysis of run 4. A plot of this significant term showed no systematic differential habituation effects, the significance of the interaction being due to a great deal of cross-over among intensities.

We conclude that, not only is the accelerative response to light absent, as Graham and Clifton suggested it might be, but so too is any consistent deceleration. Moreover, the absence of these responses is not due to rapid habituation. Nor does it appear likely that the relative unresponsiveness of HR to light stimulation is related to lower intensities of stimulation compared to sound. The lowest intensities of sound induced greater HR response than the highest light intensities. We conclude that this is an instance of stimulus specificity. Light is not an effective stimulus

to HR, at least in this experimental design. There will be

no further presentation of the results of the analysis of HR

responses to light, therefore.

The analysis of the HR response to sound within runs

revealed that mean 3 (the deceleratory mean) showed no

significant intensity effects and only one significant term,

the subsequence x intensity covariance interaction (p <

.05) on run 2. Table 1 shows the adjusted mean values

for this interaction on all runs. The absence of any

consistent trend toward differential habituation among in-

tensities of stimulation is clear. A four-way (Es groups,

intensity, subsequence and runs) analysis of variance

showed a significant difference in deceleration between

runs (p < .05). However, this difference disappeared with

covariance adjustment for differences in initial levels. In

the data of these experiments, then, there was no signifi-

cant deceleration despite the apparent deceleration evident

in Figure 1. Nor is there any trend toward greater habitua-

tion of deceleration to stimuli of higher intensity, as Graham

and Clifton hypothesized there would be if deceleration is an

OR that is replaced by acceleration (a defense response).

The analysis of variance and covariance of means 2, 4

and 5 revealed 4 and 5 to be almost entirely redundant of

mean 2. Mean 2 showed the greatest consistency in significant terms within and across runs. The procedure for selection of the values in mean 4 in most instances selected the same values as those in mean 2. Mean 5 in the absence of a significant deceleration, assumed a value dependent almost entirely on the acceleratory component best represented by mean 2. In this experiment, therefore, the difference between acceleration and deceleration was not "the most sensitive measure of cardiac response" as Geer (1964) reported. For these reasons only the analysis of mean 2 will be presented in discussing the HR acceleratory response to sound.

In every run, both the analyses of variance and covariance intensity terms were highly significant ($p < .001$), for mean 2. The reason is evident from Figure 2, where covariance adjusted values for intensity effects are presented for both sound and light. The generally monotonic acceleratory response to sound in relation to intensity is evident in every run and confirms the results of Roessler, Alexander and Greenfield (1963). The four-way analysis of variance across runs revealed a significant runs difference ($p < .05$). This was entirely attributable to differences in pre-stimulus values; the runs term was not significant in the analysis of

covariance across runs and none of the runs interaction

terms was significant. There was therefore no significant

difference in HR responsivity attributable to differences

in experimental context, although the somewhat higher

levels on runs 1 and 3 are suggestive of higher levels

under conditions of unfamiliarity and real life stress.

None of the subsequence (habituation) terms were sig-

nificant. However, the covariance intensity x subsequence

interaction terms were significant in every run (p < .05 -

.001). The adjusted values are shown in Table 2. The

accelerative component did not habituate, a result in agree-

ment with that of Geer (1964) and also with Graham and

Clifton's interpretation that phasic acceleration is a

component of the "defense reflex", rather than a part of

the orienting response. However, the significance of this

interaction of intensity with subsequence was not attributable

to lesser habituation of higher intensities or an increase in

acceleration in later subsequences.

There was only one significant accelerative term

involving Es, the analysis of covariance Es groups x

subsequence interaction on run 4 (p < .05). A plot of this

interaction showed greater acceleration in the high Es

group but no consistent difference between groups in

habituation. Plots of this interaction for the first three runs showed no consistent differences between Es groups. Possible reasons for this absence of consistent differences in relation to Es will be discussed below.

Finally, the question of reliability over testings is of interest. How consistent is the HR accelerative response to sound of individual Ss over runs? This question was answered by calculating Kendall's coefficient of concordance (Siegel, 1956). W was .778 (p < .001); individuals are highly consistent over time and life contexts.

DISCUSSION

A number of methodological issues are of importance in interpreting the foregoing results. The first of these is the effect of verbalization. In this experiment, in which no immediate verbalization was required, the range of HR acceleration in relation to the intensity of sound stimulation was from one-half to two thirds (2-4 bpm) of that in the earlier similar experiment of Roessler et al, in which immediate verbalization was required. The requirement to verbalize does increase the amount of acceleration, therefore. However, a significant degree of acceleration remains and there is no significant deceleration in the absence of the verbalization instruction, as Campos and Johnson reported.

The Campos and Johnson score, as previously noted, was based on means of 5 beats every fifteen seconds during and following stimulation. Obviously, such a score is not comparable to any of the scores used in this experiment, in which the epoch of change was only 10 seconds. Since the scores are not directly comparable no conclusive comparison can be made. By the same token, however, Campos and Johnson cannot conclude that their results refute the Laceys' hypothesis because the latter investigators also focused upon the changes occurring in briefer epochs.

Our failure to confirm the interesting hypotheses of Graham and Clifton concerning the nature of the OR and defense response of HR may also be related to method. In retrospect, it seems to us that the conditions of this experiment were such as to optimize defense responses (acceleration) and minimize the OR component (deceleration). Interview and questionaire data revealed that many Ss found the higher intensities of stimulation to be distressing, particularly in the early runs. Since the order of stimulus intensities and the intervals between stimuli were probably difficult or impossible to antici-pate accurately, the total psychophysiological "stance"

of the Ss was probably defensive and their HR response
was therefore one of acceleration to all stimuli. On the
other hand, one might argue that the constantly changing
intensity of stimulation should evoke the OR response.
All of these possibilities are conjectural, of course. A
more definitive test of Graham and Clifton's hypotheses
would be a design in which one intensity of stimulation
was continued until habituation, followed successively
by a wide range of stimulus intensities, each habituated
separately. Meyers and Gullickson (1967) did obtain
results more congruent with the Graham and Clifton
hypotheses when they employed a design somewhat like
the procedure suggested. The results of this experiment,
then, while not supporting the Graham and Clifton hypothe-
ses, do not convincingly refute them.

Other methodological problems relate to the possible
effects of initial values, level of consciusness, respiration
and rise time of stimuli. It is clear from our parallel
analyses of variance and covariance that initial value ef-
fects do occur and should be taken into account if erroneous
conclusions are to be avoided. Benjamin (1967) has
provided an excellent discussion of the applications and
interpretive implications of covariance analysis in psy-
chophysiology. Surprisingly, many of the experiments in

which HR deceleration - acceleration was studied did not

employ covariance adjustment. A related problem is one

recently defined by Schachter and his group (Williams,

Schachter and Tobin, 1967), the slope of the pre-stimulus

HR, - i.e., whether rate is decreasing or increasing at

stimulus onset. No data on the possible effects of this

variable is available in this experiment but, in view of

the numerous stimulus presentations, it seems unlikely

to have affected our results.

McDonald, Johnson and Hord (1964) reported that

response levels of HR of drowsy Ss were greater than

alert Ss and that drowsy Ss increased their HR over

trials. Since we balanced our Ss for alert-drowsy

classification within runs, it is unlikely that this variable

affected our results within runs. However, since there

were more drowsy Ss in later runs, it could have affected

between runs comparisons. We think this unlikely because

the covariance adjusted scores in later runs were actually

lower (Cf. Figure 2).

Respiration data was recorded and analyzed in this

experiment and the results will be presented elsewhere.

There was no relationship to the results reported here

for HR.

A very short rise time following stimulus onset could

evoke a HR startle response of an acceleratory type.

In this experiment the rise time of the auditory stimuli

was less than 1 millisecond; that of the visual stimuli

was less than 5 ms.   Rise time might therefore be

related to the difference between the degree of HR

acceleration to light and sound.   This seems unlikely

because 5 ms. is still a very brief rise time.   These

brief rise times might be related to the dominance of

acceleration and the absence of significant deceleration

in both modalities, however.

The absence of any consistent relationship between

HR and Es is concordant with the results of Hodges and

Spielberger (1966), who found no relationship between

manifest anxiety and HR response to threat of shock.

Anxiety is usually inversely correlated with Es, and

directly, but not always, related to physiological res-

ponsivity (Phaehler and Roessler, 1965; Roessler,

Burch and Mefferd, 1967).   However, Hein, Cohen and

Shmavonian (1966) found differences between field-

dependent and field-independent Ss.   This personality

variable is theoretically related to ego strength.   The

possibility remains that stimuli which evoke a greater

range of HR response than the range obtained in this

experiment would show differences related to Es.

REFERENCES

Benjamin, L. S. Facts and artifacts in using analysis of covariance to "undo" the law of initial values. Psychophysiology, 1967, 4:187-206.

Campos, J. J. & Johnson, H. J. The effects of verbalization instructions and visual attention on heart rate and skin conductance. Psychophysiology, 1966, 2:305-310.

Campos, J. J. & Johnson, H. J. Affect, verbalization and directional fractionation of autonomic responses. Psychophysiology, 1967, 3:285-290.

Chase, G. C. & Graham, F. K. Heart rate response to non-signal tones. Psychon. Sci., 1967, 9(4):181-182.

Dahlstrom, W. G. & Welsh, G. S. (Eds.) An MMPI Handbook. Minneapolis: University of Minnesota Press, 1960.

Galbrecht, C. R. & Dykman, R. A. On the scoring of heart rate: Reply to criticisms. Psychophysiology, 1965, 2:42-46.

Geer, J. H. Measurement of the conditioned cardiac response. J. Comp. Physiol. Psychol., 1964, 57:426-433.

Graham, F. K. & Clifton, R. K. Heart-rate change as a component of the orienting response. Psychological Bull., 1966, 65:305-320.

Hein, P. L., Cohen, S. I. & Shmavonian, B. M.   Perceptual mode and cardiac conditioning.   Psychophysiology, 1966, 3:101-107.

Hodges, W. F. & Spielberger, C. D.   The effects of threat of shock on heart rate for subjects who differ in manifest anxiety and fear of shock.   Psychophysiology, 1966, 2: 287-294.

Johnson, L. C. & Lubin, A.   The orienting reflex during waking and sleeping.   Electroenceph. Clin. Neurophysiol., 1967, 22:11-21.

Lacey, J. I., Kagan, J., Lacey, B. C. & Moss, H. A.   The visceral level: Situational determinants and behavioral correlates of autonomic response patterns.   Chap. 9 in Knapp, P. H. (Ed.) Expression of the Emotions in Man, New York: International University Press, 1963.

Lang, P. H. & Hnatiow, M.   Stimulus repetition and the heart rate response.   J. Comp. Physiol. Psychol., 1962, 55:781-785.

Lindquist, E. F.   Design and Analysis of Experiments in Psychology and Education.   Boston: Houghton Mifflin Co., 1953.

McDonald, D. G., Johnson, L. C. & Hord, D. J.   Habituation of the Orienting response in alert and drowsy subjects. Psychophysiology, 1964, 1:163-173.

Meyers, W. J. & Gullickson, G. R.   The evoked heart
rate response: the influence of auditory stimulus
repetition, pattern reversal and autonomic arousal
level. Psychophysiology, 1967, 4:56-66.

Obrist, P. A.   Cardiovascular differentiation of sensory
stimuli. Psychosom. Med. , 1963, 25:450-459.

Pfaehler, G. T. & Roessler, R.   Ego strength and glucose
tolerance. J. Psychosom. Res., 1965, 8:431-439.

Roessler, R. , Alexander, A. A. & Greenfield, N. S.   Ego
strength and physiological responsivity. Arch. Gen.
Psychiat. , 1963, 8:142-154.

Roessler, R. , Burch, N. R. & Childers, H. E.   Personality
and arousal correlates of specific galvanic skin responses.
Psychophysiology, 1966, 3:115-130.

Roessler, R. , Burch, N. R. and Mefferd, R. B. , Jr. ,
Personality correlates of catecholamine excretion under
stress. J. Psychosom. Res., 1967, 11:181-185.

Siegel, S. , Nonparametric Statistics for the Behavioral
Sciences. New York: McGraw Hill, 1956.

Uno, T. & Grings, W. W.   Autonomic components of
orienting behavior. Psychophysiology, 1965, 1:311-321.

Weiner, H.   Some psychologic factors related to cardio-
vascular responses: A logical and empirical analysis.
In Roessler, R. & Greenfield, N. S. (Eds.)
Physiological Correlates of Psychological Disorder.

Madison: University of Wisconsin Press, 1962.

Williams, T. A. ; Schachter, J. & Tobin, M. Spontaneous variation in heart rate: Relationship to the average evoked heart rate response to auditory stimuli in the neonate. Psychophysiology, 1967, 4:104-111.

FOOTNOTES

1. Copies of the summary tables of the analyses of variance

   and covariance are available from the first author on

   request.

LEGENDS FOR FIGURES

Figure 1.   Beat-by-beat pattern of the heart rate response to 5

intensities of sound and light.   Each data point is the mean

for all subjects.   Note the definite acceleration to sound

occurring in the first 5 beats, ~~the deceleration occurring~~

~~in the first 5 beats,~~ the deceleration occuring between

beats 5-10 and the lack of consistent pattern of response

to light.   Rates are unadjusted.   (See text for explanation

and for intensities in db.)

Figure 2.   Heart rate acceleration to 5 intensities of sound

and light on four occasions.   Note the generally mono-

tonic relationship between sound stimulus intensity and

heart rate and the lack of relationship to intensity for

light.   Note also the decreasing level of heart rate over
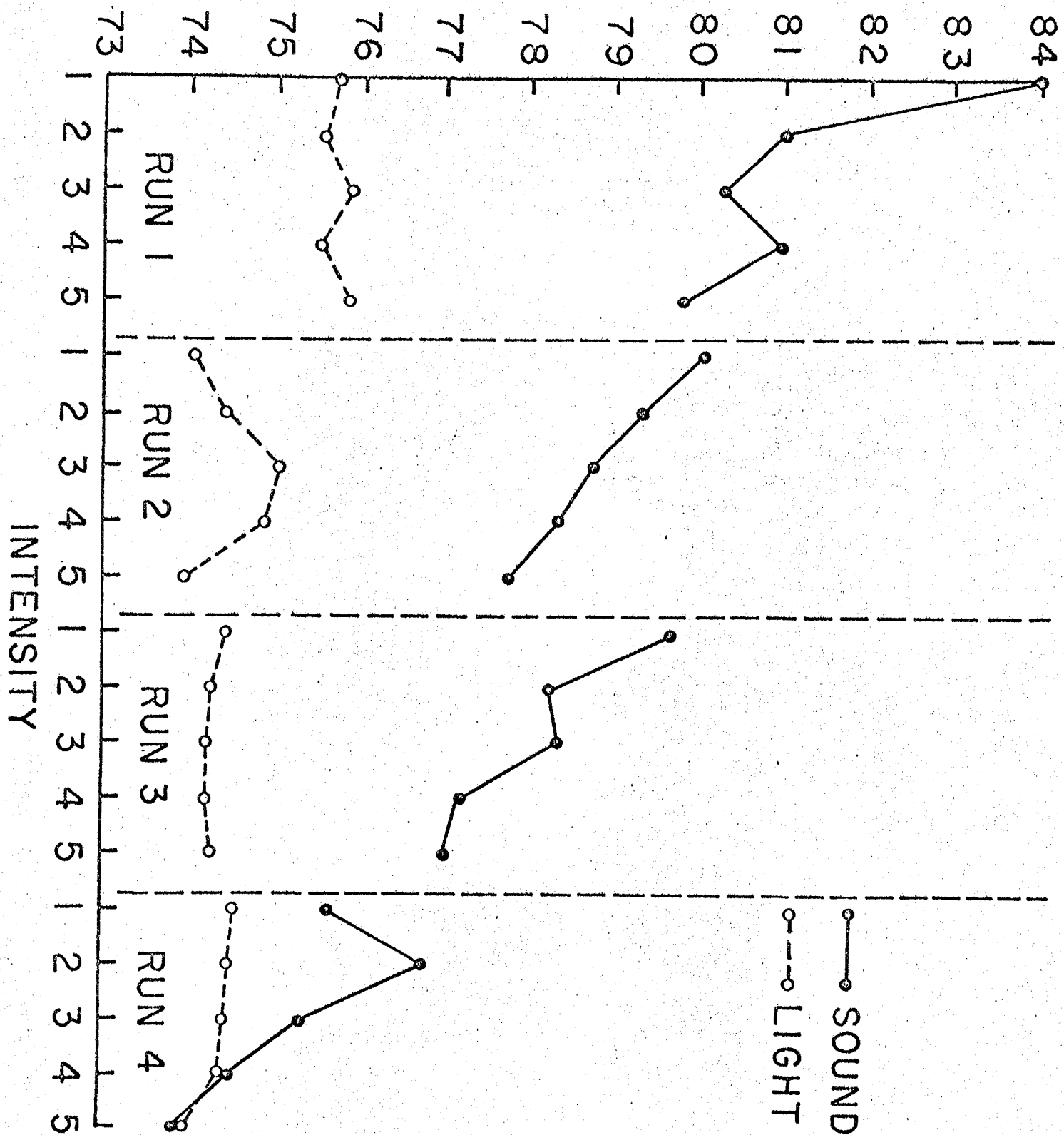
repeated testings.
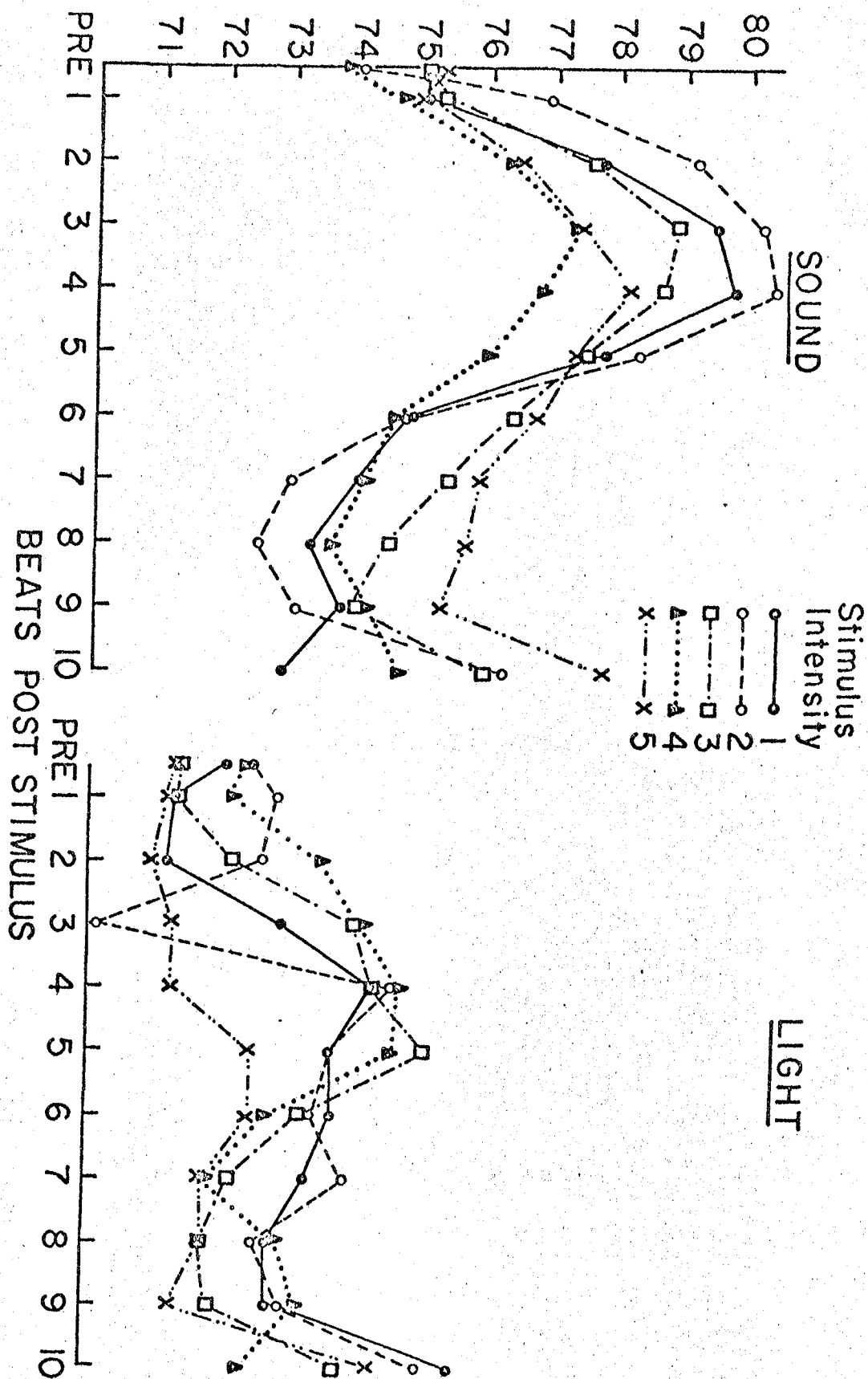
Table 1

Heart Rate Deceleration to Five Intensities of Sound

Over Five Subsequences

Subsequence		Run 1					Run 2					Run 3					Run 4			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Intensity 1	77.5	76.0	75.0	75.9	78.6	75.2	75.6	73.0	74.4	71.1	71.9	72.7	71.4	71.0	71.9	68.8	66.9	68.3	69.2	69.5
2	75.3	76.5	76.2	75.9	76.7	74.8	76.3	73.9	72.0	74.7	72.3	72.3	72.1	71.4	72.8	69.9	68.5	69.0	68.0	70.0
3	75.0	76.8	77.4	76.7	77.8	74.9	75.1	73.1	74.8	76.1	70.9	72.2	72.7	71.5	69.8	68.9	69.7	69.0	68.7	69.6
4	75.0	76.8	76.6	77.0	77.4	75.6	73.9	74.1	74.2	74.3	72.2	73.6	73.0	71.2	71.4	71.9	67.5	67.8	68.2	69.7
5	74.2	76.4	76.6	75.6	75.9	75.1	73.7	73.9	75.2	74.0	71.1	73.2	69.9	72.4	73.3	69.3	68.1	68.9	69.7	70.2

Table 2

Heart Rate Acceleration to Five Intensities of Sound

Over Five Subsequences

Subsequence	Run 1					Run 2					Run 3					Run 4				
Intensity	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	84.8	85.1	83.2	82.0	84.1	83.6	81.0	78.7	79.3	79.5	80.8	80.3	79.3	79.3	80.0	78.1	77.2	76.2	77.4	77.7
2	82.1	80.9	81.6	81.2	81.4	81.1	79.1	79.4	78.9	78.2	79.4	77.4	77.5	78.7	78.3	76.9	75.8	75.5	76.8	75.3
3	81.2	82.0	81.1	80.4	80.6	79.3	78.8	78.6	77.9	79.6	78.8	79.5	76.8	77.8	77.3	74.5	75.7	74.6	75.4	75.5
4	79.9	80.3	80.0	82.0	80.8	78.6	78.2	78.5	77.5	78.6	76.8	78.5	76.9	77.5	77.7	74.8	74.2	74.2	76.1	73.9
5	77.8	79.2	79.2	79.4	79.6	77.4	77.6	77.2	79.8	77.3	76.1	76.3	75.7	76.1	76.2	72.9	72.7	74.0	73.6	73.5